

Physics Impact

The Fermilab physics program together with the computational facilities at Fermilab have lead to several important high-profile results.



———— B_c mass prediction ————

“In an unprecedented feat of computation, particle theorists made the most precise prediction yet of the mass of the ‘charm-bottom’ particle. Days later, experimentalists dramatically confirmed that prediction”,
Nature **436** (2005)

AIP Physics News Update: “*Most Precise Mass Calculation For Lattice QCD*” listed among **The Top Physics Stories for 2005**

“*Mass of the $B(c)$ meson in three-flavor lattice QCD*”, I. Allison, et al., Phys. Rev. Lett. **94** (2005).



f_{D^+} prediction

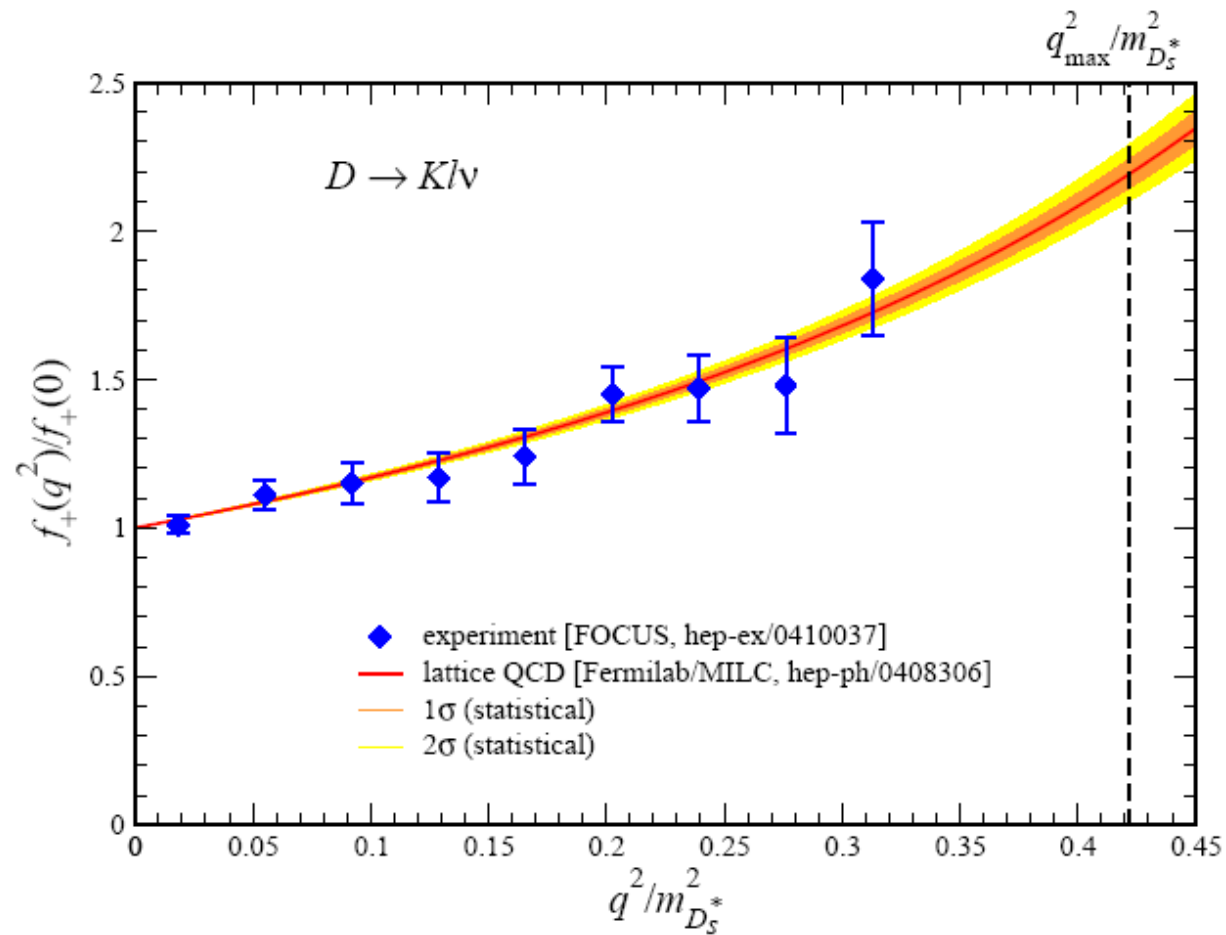
“It became clear that both groups (CLEO and LQCD) could have substantial results just in time for the Lepton-Photon Symposium in Uppsala at the end of June. Since both communities felt that it was very important for the LQCD result to be a **real prediction**, they agreed to embargo both of their results until the conference... The two results agree well within the errors of about 8% for each.” CERN Courier **45**, 6 (2005).

C. Aubin, *et al.*, Phys. Rev. Lett. **95** (2005) 122002



$D \rightarrow K \ell \nu$

The shape of $f_+(q^2)$ was predicted by LQCD before FOCUS and Belle [hep-ex/0510003] results published.



USQCD physics goals

| Measurement | CKM Matrix Element | Hadronic Matrix Element | Expt. Error | Current Lattice Error | Lattice Error 0.5 TF-Yr | Lattice Error 10 TF-Yr |
|--|----------------------|---|------------------|-----------------------|-------------------------|------------------------|
| ΔM_{B_d} ($\bar{B}B$ mixing) | $ V_{td} ^2$ | $f_{B_d}^2 B_{B_d}$ | 4% | 35% | 18% | 9% |
| $\Delta M_{B_s}/\Delta M_{B_d}$ | $ V_{ts}/V_{td} ^2$ | $f_{B_s}^2 B_{B_s}/f_{B_d}^2 B_{B_d}$ | Not yet measured | 20% | 5% | 3% |
| ϵ ($\bar{K}K$ mixing) | $\text{Im} V_{td}^2$ | B_K | 2% | 20% | 10% | 5% |
| $B \rightarrow (\rho_\pi) l \nu$ | $ V_{ub} ^2$ | $\langle \rho_\pi (V-A)_\mu B \rangle$ | 25% | Calc. in progress | 15% | 5–10% |
| $B \rightarrow (D^*_D) l \nu$ | $ V_{cb} ^2$ | $ \mathcal{F}_{B \rightarrow (D^*_D) l \nu} ^2$ | 2% | Calc. in progress | 6% | 3% |

CDF: 2% measurement; D^0 : two-sided limit



— Current production runs —

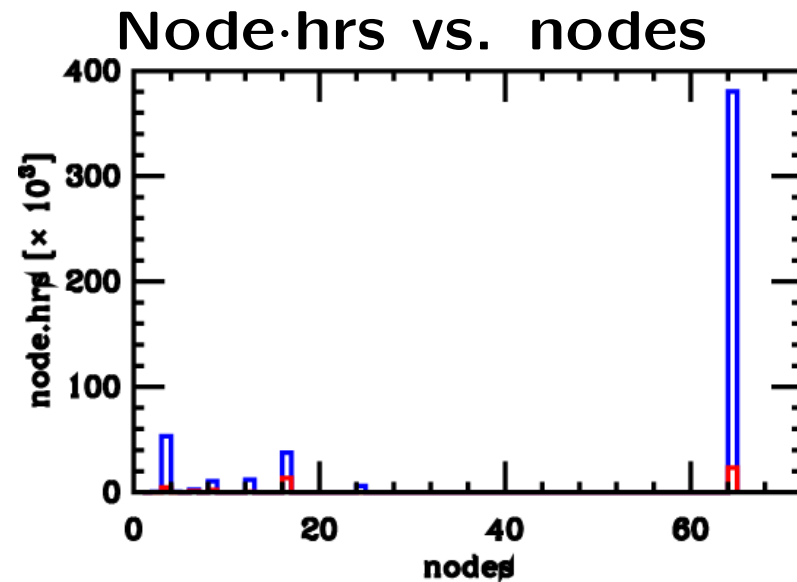
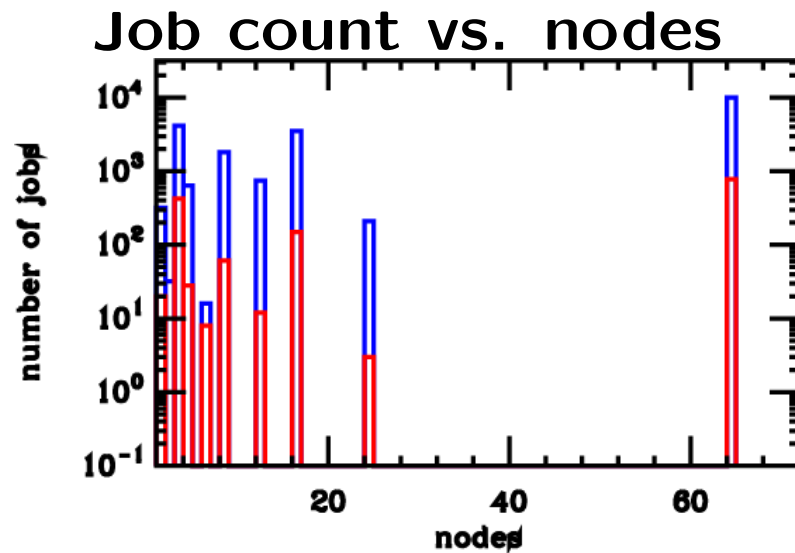
| project | lattices |
|----------------------------------|--|
| f_{D^+} and f_{B_d} | $40^3 \times 96$ and $28^3 \times 96$ |
| HQET Λ and λ_1 | $20^3 \times 64$ and $16^3 \times 48$ |
| $B \rightarrow \pi \ell \nu$ | tests $20^3 \times 64$ |
| $B \rightarrow D^{(*)} \ell \nu$ | tests $20^3 \times 64$; bulk of next alloc. |
| thermodynamics | various; MILC collab. |
| $B-\bar{B}$ mixing | starting |
| $K-\bar{K}$ mixing | tests DWF; next alloc. period |

Production issues

- HL decay constant runs uses a workflow framework (perl) originally written for ACPMAPS. Helps to run, monitor and checkpoint restart multiple production streams. Required perl expertise is a barrier to prospective users.
- Postdocs have written a hierarchy of bash scripts to coordinate running of HQET and SL decay projects.
- Scripting overhead to detect, log and respond to exceptions in runs. Restarting not always automatic.
- Some wrappers for file copies, mpirun and testing batch job exit status.
- Production runs almost completely moved to lqcd volatile dcache to store intermediate results.



Production throughput



- usage dominated by $40^3 \times 96$ quark solves (nodes=64)
- blue: totals, red: fraction with non-zero exit status
- $\mathcal{O}(8\%)$ of 64 node jobs need restart

—— Dcache i/o performance ——

- metrics obtained from production run
- 26 indep. streams of analysis (fills pion cluster)
- dcache copies of 1.77, 4.42 and 7.08 GB files
- average rates per copy reported by dccp
- lqcd: writes 9^{+2}_{-3} (vol) and 7^{+3}_{-2} (vol→pub) MB/s
- pion: vol. 10^{+4}_{-4} (read) and 36^{+4}_{-5} (write) MB/s

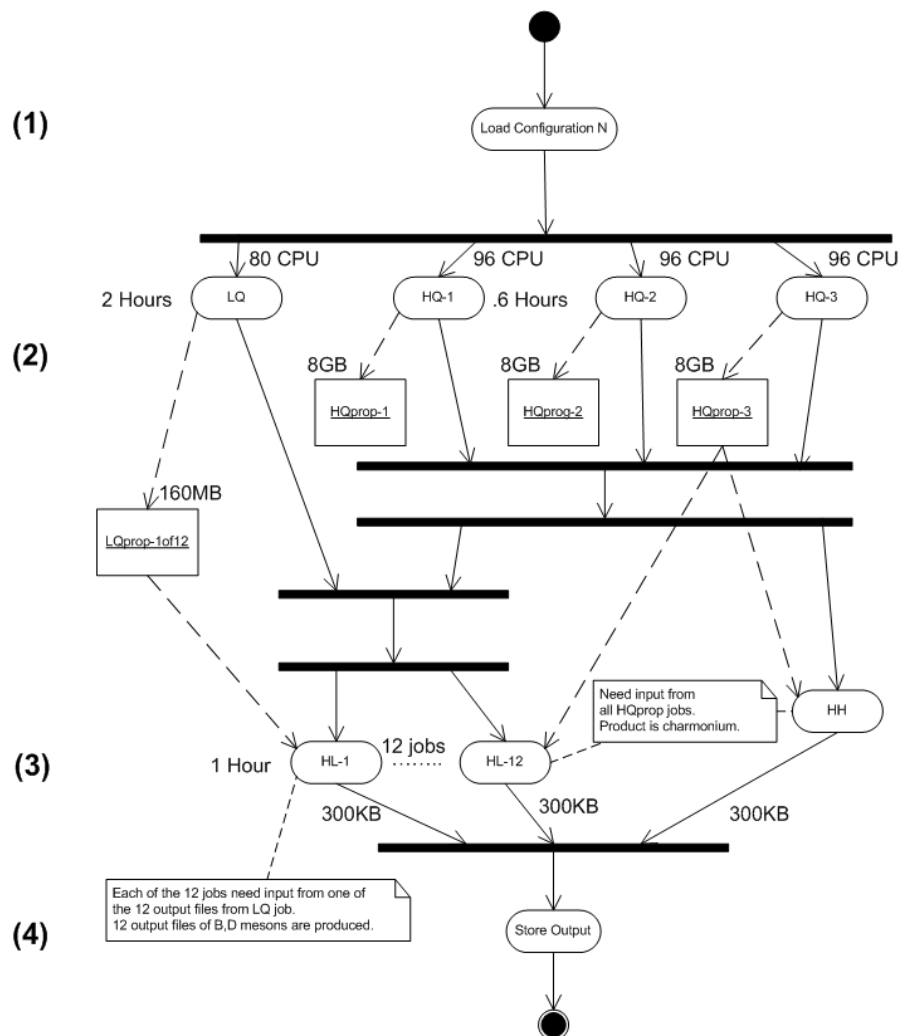
I/O for parallel job funnels through a single i/o node.

Bigger lattices will require each node do own i/o.



Example Workflow

Example workflow: 2-pt analysis for processing configuration N



- HL and HH analysis for a single configuration
- analysis of one configuration an independent unit of work
- Directed Acyclic Graph (DAG)
- arrows: dependencies among steps (data)
- decorations: resource requirements (e.g. cpu·hrs, disk space)

— Why a Workflow Framework? —

As facility capabilities increase, campaigns will consist of many more emarrassingly parallel streams of analysis. Useful to have a framework to manage running and competition for resources.

- Help plan/schedule analysis campaigns
- Predict total resource requirements
- Automate execution and monitoring of an analysis campaign
- Coordinate facility-wide resource usage during a campaign – avoid potential resource bottlenecks



– Features of a Workflow System –

Workflow system will integrate existing and planned components of the standard user environment.

- A workflow language useful for describing an analysis campaign.
- Tools to aid in designing and validating workflow language documents.
- Management (storage & retrieval) of workflow specifications.
- Tools to plan, schedule and run a workflow.

Features Continued ...

- Tools to monitor work progress and track performance metrics.
- Components capable of detecting and reacting to conditions arising in performance and monitoring data.
- Lifetime management of intermediate data in order to maximize resource utilization (e.g. disk space, network bandwidth, memory, CPU).

SciDAC-II Proposal

Workflow project is part of the LQCD SciDAC-II proposal.

- Xian-He Sun (IIT, guest scientist), L. Piccoli, J. Kowalkowski (liason), J. Simone
- specification for prototype 10/06
- profiling and workflow simulations 12/06

